

1 GRAPHIC DISPLAY OF NETWORK PERFORMANCE INFORMATION

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Background of the Invention

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The present invention relates to telecommunications management systems and, more particularly, to an improved process for graphically displaying network performance information in a manner which is compact, organized, and intuitive to use.

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Telecommunications facilitate the interactions which are necessary or desirable for many aspects of modern life, including business affairs, personal relationships, education, government functions, entertainment, and the like. Telephone systems function to establish a temporary electronic communication channel between a caller and a called party and carry electronic signals therebetween which represent the information communicated by the parties. A temporary communication channel, or call, is generally established between telephone lines of the communicating parties through "switches" which establish the particular channel and multiple line trunks which carry the communication signal between switches. The number of calls

1 which can be simultaneously accommodated is limited by the
2 number of switches and trunk lines available, that is, the
3 total number of functioning switches and trunk lines in
4 existence which are not currently occupied with calls or
5 other "traffic".

6 Traffic on communication networks can include signals
7 carrying actual vocal conversations between humans, as well
8 as data such as communications among distributed computer
9 systems, electronic financial transactions, facsimile
10 signals, internet "surfing", email exchanges, network
11 housekeeping data, and the like. New telecommunications
12 technologies are emerging which will make further use of
13 network throughput, such as on-line commerce, video
14 teleconferencing, on-demand video entertainment,
15 transmission of high quality medical images, remote control
16 and monitoring applications, and the like.

17 Network traffic varies over time and date and by
18 locality. Economics prevent network operators from
19 providing even remotely sufficient capacity for all users to
20 access the network simultaneously, since a large proportion
21 of such capacity would be idle most of the time,
22 constituting a wasted investment. In practice, telephone
23 network operators attempt to provide adequate capacity to
24 accommodate peak traffic, with some spare capacity to take

1 care of unexpected traffic peaks, temporary local service
2 outages, and short term growth. Operators of networks
3 attempt to make the best use of existing capacity by
4 efficient balancing of traffic loads through available
5 switches and trunks by means of selective routing of calls.
6 Because of the importance of activities supported by
7 telecommunications and the volume of traffic,
8 telecommunications network operators strive to maximize "up
9 time" for components of the network as well as the
10 technological quality of communication signals.

11 In order to carry out the mission of availability and
12 quality, network operators must effectively monitor the flow
13 of traffic and the performance quality of the network
14 components. By such monitoring, congestions in traffic
15 flow, equipment malfunctions, degradations in operation, and
16 the like can be detected and acted upon. The diversity of
17 factors and volume of data which must be sampled, updated,
18 accumulated, organized, and presented in a meaningful way to
19 effectively monitor the network are immense. It has been
20 common practice to provide such data in text-based tabular
21 or spreadsheet form, although graphical presentation of such
22 data has also been implemented. The data thus provided may
23 be either printed out or accessed and displayed in graphic
24 form. A problem in the past has been the number of

1 functions to be monitored, the physical difficulty in
2 finding desired data within the mass of data available,
3 interpretation of the significance of observed variations in
4 data, and nonintuitive navigation of screens of displayed
5 data.

6 What is needed is a method of displaying a large amount
7 of diverse data in such an organized manner that problems
8 can be quickly noticed and isolated as quickly as possible
9 for corrective action.

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11 Summary of the Invention

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13 The present invention provides a graphic process for
14 compact and efficient presentation of a large and diverse
15 quantity of data, particularly performance data of a digital
16 communication network. The process of the present invention
17 monitors a number of communication network functions and
18 maps indexes of the functions as colors onto a set of nested
19 or hierarchically organized displays. The displays are
20 identified by labels, and graphic selection opens lower
21 levels or further breakdowns of the data which can be
22 presented as graphics, tables, or the like.

23 The preferred display process makes use of a technique
24 for representing various types of hierarchical arrangements

1 of data known as "treemaps". Development of treemap
2 techniques is believed to have begun in the early 1990's,
3 and are treemaps referred to in U. S. Patent No. 5,581,797.
4 In the present invention, an area of display is divided into
5 a number of rectangular divisions, each associated with a
6 particular communication network function, and labeled to
7 indicate the function monitored. In some cases, display
8 divisions may be subdivided into display subdivisions which
9 reflect the overall organization of the function monitored.
10 For example, display subdivisions could indicate an
11 organization of a network function according to geographic
12 regions, particular communication services, major customers,
13 or the like.

14 Each network function is numerically scored according
15 to some practical measure such as the volume of performance,
16 speed of performance, quality of performance, or other
17 criteria, as appropriate for the function monitored. Some
18 functions may be scored in a binary manner, such as merely
19 good or bad. Others may be scored within a range of
20 gradations between excellent and undesirable. Most of the
21 network functions are conventionally monitored in numeric
22 terms, such that it is only necessary to covert the reported
23 numeric information for each monitored function into a
24 convenient scale.

1 In the process of the present invention, a color scale
2 is devised to graphically or visually represent the numeric
3 scores, such as green for a most desirable score, red for a
4 most undesirable score, yellow for a median score, and
5 mixtures for scores in between. The color assigned to a
6 given score for a given function is then applied to the
7 display division associated with the function to give an
8 immediate visual indication of the relative performance of
9 the function. Alternatively, variations in other graphic
10 qualities of the display divisions can be correlated to the
11 performance of the function monitored, such as gray scale
12 shading, size of the rectangles, or the like.

13 The display area is accessible, for example, over a
14 computer network, such as a local area network (LAN), an
15 intranet, the internet, or the like. Preferably, a
16 graphical application is used to enable information about
17 the network functions to be accessible by graphical
18 selection of the display area. The display process of the
19 present invention may include provisions for immediate
20 information display, such as by the use of "mouseover pop-up
21 balloons" which open whenever a mouse cursor is placed on a
22 display division or subdivision. The balloons preferably
23 include information, such as numeric information, related to
24 the function associated with a particular display division

1 or subdivision. Actual selection of a display division or
2 subdivision opens up a deeper layer of the graphic process
3 which may be organized as a graphic display, a tabular or
4 spreadsheet display of text, or the like. The lower levels
5 of display may also include graphic display areas which are
6 divided and subdivided as necessary. Alternatively, the
7 lower levels may be conventional graphs of various types,
8 such as line graphs, bar graphs, pie charts, Cartesian
9 graphs, or the like.

10 Any of a number of network functions can be monitored
11 using the processes of the present invention including, but
12 not limited to: voice quality, fax quality, traffic volume,
13 call setup time, call completions, and loss of
14 synchronization or data error rates; the performance quality
15 of certain network components, such as echo cancellers,
16 switches, digital communication multiplexing equipment
17 (DCME), and wavelength division multiplexing (WDM)
18 equipment; and proprietary communication products using the
19 communication network. The top level display division of
20 any function can be assigned a single composite performance
21 index and associated color or, alternatively, may be
22 subdivided into major organizational categories with a
23 performance index and color indicating the performance of
24 each functional subdivision.

1 Other objects and advantages of this invention will
2 become apparent from the following description taken in
3 relation to the accompanying drawings wherein are set forth,
4 by way of illustration and example, certain embodiments of
5 this invention.

6 The drawings constitute a part of this specification,
7 include exemplary embodiments of the present invention, and
8 illustrate various objects and features thereof.

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10 Brief Description of the Drawings

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12 Fig. 1 is a block diagram illustrating components of a
13 system for practicing the graphic display of network
14 performance information of the present invention.

15 Fig. 2 is a diagrammatic view of a top level of a
16 graphic display of network performance information,
17 illustrating major network functions being monitored.

18 Fig. 3 is a diagrammatic view illustrating one of the
19 major network functions being monitored by the system of the
20 present invention, with labels representing colors
21 associated with subdivisions of the network function.

22 Fig. 4 is a fragmentary diagrammatic view of a second
23 level of the graphic display illustrating subdivisions of a
24 major network function and further illustrating a mouseover

1 pop-up balloon providing further detailed information
2 regarding a display subdivision on which a mouse cursor is
3 placed.

4 Fig. 5 is a diagrammatic view of a subdivision detail
5 page displayed in response to selection of a particular
6 display subdivision in Fig. 4.

7 Fig. 6 is a simplified flow diagram illustrating
8 process steps for graphically displaying network performance
9 information according to the present invention.

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11 Detailed Description of the Invention

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13 As required, detailed embodiments of the present
14 invention are disclosed herein; however, it is to be
15 understood that the disclosed embodiments are merely
16 exemplary of the invention, which may be embodied in various
17 forms. Therefore, specific structural and functional
18 details disclosed herein are not to be interpreted as
19 limiting, but merely as a basis for the claims and as a
20 representative basis for teaching one skilled in the art to
21 variously employ the present invention in virtually any
22 appropriately detailed structure.

23 Referring to the drawings in more detail, the reference
24 numeral 1 (Fig. 6) generally designates a process for

1 graphically displaying network performance information
2 according to the present invention. In general, the process
3 1 monitors a plurality of communication network functions
4 having numeric or qualitative indexes of performances,
5 proportions each index to a color scale, and displays the
6 associated colors on a labeled primary display 3 (Fig. 2),
7 divided according to the monitored network function. The
8 primary display 3 links to secondary levels 4 (Fig. 4) and,
9 possibly, tertiary levels 5 (Fig. 5) and other lower levels
10 (not shown) to provide organized and intuitive access to
11 network performance data to thereby enable quick, and
12 efficiently directed, response to network problems.

13 Fig. 1 illustrates principal components of a simplified
14 exemplary hardware arrangement 8 through which the process 1
15 of the present invention can be practiced. The hardware 8
16 includes a network performance server 9 which communicates
17 with a number of platforms 10 which monitor various
18 functions 11 of a digital communication network (not shown),
19 such as a telephone network. The performance server 9
20 communicates with the platforms 10 over a computer network
21 12, such as a local area network, intranet, or the like, of
22 the communication network operator. Network operators
23 typically monitor a number of functions 11 of their network
24 for performance factors to enable optimization of

1 performance and correction of any problems that arise. The
2 displays 3-5 of the process 1 may be accessed by an operator
3 computer 15 through the computer network 12 and presented on
4 an operator computer display device 16. The operator
5 computer 15 and display device 16 may be monitored by a
6 representative of the communications network operating
7 company, such as a manager, engineer, technician, or the
8 like.

9 Fig. 2 illustrates an exemplary top-level or primary
10 display screen 3 of the process 1. The primary screen 3
11 displays a graphic figure or object 20 for each major
12 network function 11 monitored. The illustrated graphic
13 objects 20 are rectangular blocks which are assembled into
14 the rectangular matrix 18. The objects 20 are, thus,
15 displayed as divisions of the primary display 3. Other
16 shapes could, alternatively, be employed for the objects 20
17 and could be organized in a manner other than the
18 rectangular matrix 3 shown in Fig. 2.

19 The network functions 11 which are monitored can
20 include specific equipment components, such as switches,
21 echo cancellers, digital communication multiplexing
22 equipment (DCME), demultiplexing equipment (DAC's), and
23 wavelength division multiplexing equipment (WDM); signal
24 quality of various transmission modes, such as voice signal

1 quality, facsimile (fax) signal quality, asynchronous
2 transfer mode (ATM) quality, digital signal processing
3 performance, and synchronization performance (SLIPS & LOF's
4 (loss of frames)); communication traffic functions, such as
5 traffic volume, call setup time, and call completions; and
6 the performance quality of proprietary communication
7 products and services. The functions 11 illustrated in Fig.
8 2 are exemplary and not intended to be exhaustive. The
9 platforms 10 may be combinations of hardware and software
10 which enable operation of the network functions or which
11 monitor their operation. The platforms 10 and functions 11
12 are conventional and do not form parts of the process 1 of
13 the present invention, but provide data which is processed
14 by the present invention.

15 Some of the functions 11 illustrated in Fig. 2 are
16 subdivided into function subdivisions, symbolized by object
17 subdivisions 22 in Figs. 2 and 3. Such subdivisions of the
18 functions 11 reflect the operational organization of such
19 network functions 11, as by geographic region, major
20 customers, classes of service, or any other appropriate
21 category. Each of the objects 20 is labeled to indicate the
22 function 11 monitored. Although not shown or indicated in
23 Fig. 2, each of the objects 20 or subdivisions 22 thereof is
24 colored according to a color scale proportioned to a range

1 of numeric indexes of performances determined for the
2 functions 11 associated with the objects 20 and object
3 subdivisions 22. The colors assigned to the objects 20
4 and/or subdivisions give an immediate visual indication of
5 problems with the associated network function 11, on the one
6 hand, and the effect of any corrective actions which are
7 taken to relieve any detected problems.

8 Fig. 3 shows a graphic object 20 for monitoring the
9 voice quality of communication signals on the network. The
10 voice quality object 25 is subdivided, as by geographic
11 region, and each subdivision 22 has an indication of a
12 color, such as variations of greens, yellows, and reds, such
13 as green (GRN), medium green (MED GRN), light green (LT
14 GRN), or the like. Each subdivision 22 may represent an
15 additional plurality of areas, for example, a number of
16 cities, as is shown by a secondary voice quality level 27
17 (Fig. 4). The color assigned to any of the subdivisions 22,
18 which may also be referred to as secondary objects, may be
19 scaled to an average of the geographic regions associated
20 with it or, alternatively, by a worst scoring component of
21 the region. A color scale from green for good to red for
22 bad is preferred. However, other sets of colors,
23 monochromatic tones, graphic patterns, or the like could

1 also be employed to graphically indicate the quality of a
2 given division or subdivision of an object.

3 Graphic selection of one of the subdivisions 22 causes
4 a corresponding secondary level 4,27 to be displayed. The
5 illustrated secondary display 27 shown in Fig. 4 monitors
6 network voice quality in a number of southeastern cities of
7 the United States, which are shown as tertiary objects 30.
8 Although not indicated in Fig. 4, preferably each object 30
9 is color coded according to a performance scale for the
10 corresponding city. the color coding gives an immediate
11 indicate of relative voice quality for calls to each city
12 monitored.

13 The process 1 preferably includes the capability of
14 quickly giving more detailed summaries of performance of the
15 functions 11 and subdivisions and tertiary categories 30
16 thereof. The process 1 makes use of a common graphic
17 technique known as "mouseover popup balloons" for this
18 purpose. Referring to Fig. 4, a mouse cursor 33 is placed
19 on a tertiary object 30, such as the city of Atlanta,
20 Georgia without "clicking" or selecting the object. The
21 process 1 detects the location of the cursor 33 and causes
22 the display of a popup balloon 35 showing a numeric summary
23 of the voice quality scores for the corresponding city.
24 Mouseover popup balloons are commonly used in software with

1 graphical user interfaces to function as a type of
2 immediate, context sensitive help feature to indicate, for
3 example, the function of tool icons on a tool bar of the
4 software display. The mouseover popup balloons 35 may be
5 used with any of the levels 3-5 of the process 1, as is
6 appropriate, to give a more detailed degree of data than
7 simply the relative color of the associated objects 20, 22,
8 or 30. The data displayed in the illustrated balloon 35 in
9 fig. 4 is a set of averages of "figure of merit" for voice
10 quality test calls placed over a plurality of networks to
11 the monitored city.

12 Placing the mouse cursor 33 on an object 30 and
13 selecting the object, by "clicking" or operating a selection
14 switch, causes the process 1 to display the tertiary display
15 5 (Fig. 5) which is a further detailed summary, or
16 subdivision detail page, of voice quality tests for the
17 selected city, shown in a table format. The voice test
18 table 37 illustrated includes the monitored city 42, the
19 dates of the test calls 43, the test call origin locations
20 44, the networks used 45, the figure of merit or scores 46
21 for the test calls, and the test call identification number
22 47. The specific content of the secondary and tertiary
23 display levels 4 and 5, and any lower levels, depends on the
24 nature of the network function 11 monitored through the

1 objects 20 and will vary as is appropriate. Lower levels
2 may be graphically oriented , as treemap levels or other
3 graphic displays, or may be text or table based, depending
4 on the source of data and the most convenient way of
5 presenting the data.

6 Fig. 6 summarizes operation of the network performance
7 display process 1 of the present invention, as on the
8 network performance server 9. The server 9 includes
9 hardware and appropriate software to process the data
10 queried from the function monitor platforms 10 regarding the
11 network functions 11 to generate the displays 3-5 and links
12 thereamong. Since the network functions 11 are diverse in
13 nature, some scaling of indexes of performance is required.
14 For this purpose, each function 11 monitored requires the
15 entry of corresponding configuration factors 40 (Fig. 1).
16 The configuration factors 40 preferably convert the ranges
17 of indexes of performance for the monitored functions to
18 convenient scales and proportion the converted ranges of
19 indexes to the ranges of colors to be displayed for the
20 objects 20, 22, 30, and the like. Additionally, the
21 configuration factors 40 determine the manner of displaying
22 the object 20 associated therewith, the type of lower
23 display levels 4 or 5, the types of any subdivisions 22, the
24 type and manner of any popup balloons 35, and further

1 specifications of the type and manner of information
2 associated with any object 20.

3 Referring to Fig. 6, the process 1 displays the graphic
4 objects 20 at step 50, links the objects 20 to the network
5 functions at step 51, and links object subdivisions 22, if
6 any, to subdivisions or subcategories of the functions 11 at
7 step 52. At step 53, the function and subdivision indexes
8 of performance or values are scaled to the colors to be
9 displayed on the process displays 3-5. The scaling step 53
10 makes use of the configuration factors 40 entered into the
11 network performance server 9. The process 1 then enters a
12 main loop 55.

13 In the main loop 55, the process 1 queries the function
14 platforms 10 for the current values of the functions 11 at
15 step 57 and displays object colors for the function values
16 obtained at step 58. Similarly, the process 1 queries the
17 any function subdivisions for their corresponding values at
18 step 59 and displays the subdivision colors for the
19 subdivision values obtained at step 60. The process 1
20 continually tests for and detects mouseovers of any graphic
21 objects 20 at test 62, mouseovers of any graphic
22 subdivisions 22 at test 63, the selection of any object 22
23 at test 64, or the selection of any subdivision object 22 at
24 test 65. If a mouseover is detected at test 62 or 63, the

1 process 1 displays respectively a function value summary at
2 step 67 or a subdivision value summary at step 68, as by
3 displaying a popup balloon 35. If an object 20 is selected
4 at test 64 or a subdivision object 22 is selected at test
5 65, the process 1 goes respectively to a function detail
6 page at step 69 or to a subdivision detail page at step 70.
7 Depending on the nature of the object 20 or subdivision
8 object 22 selected, and the network function 11 associated
9 therewith, the detail page may be in the form of a secondary
10 display 4, a tertiary display 5, or the like. Once the
11 process 1 transfers to a detail page at step 69 or 70,
12 depending on the configuration of the next level, the
13 process 1 may enter a new processing loop similar to the
14 main loop 55. Although not illustrated, each display 4 or 5
15 below the main display 3 preferably has a link back to the
16 next higher levels of the process 1.

17 In a similar manner, the remaining graphic objects 20
18 are linked to more detailed information regarding the status
19 or performance of the network functions 11 they monitor.
20 Some objects 20 may link directly to tabular displays
21 similar to the voice quality table 37. Others may link to
22 arrangements of secondary or tertiary graphic objects 22 or
23 30 which, in turn, link to further graphic objects, graphic
24 displays, tabular displays, or simply alphanumeric

1 expressions of data. The principal objective of the process
2 1 is to organize a large universe of data into a manageable
3 arrangement of data which can be intuitively navigated to
4 effectively monitor the operation of a large communication
5 network and respond to problems and situations which can
6 occur in such operation.

7 It is to be understood that while certain forms of the
8 present invention have been illustrated and described
9 herein, it is not to be limited to the specific forms or
10 arrangement of parts described and shown.

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